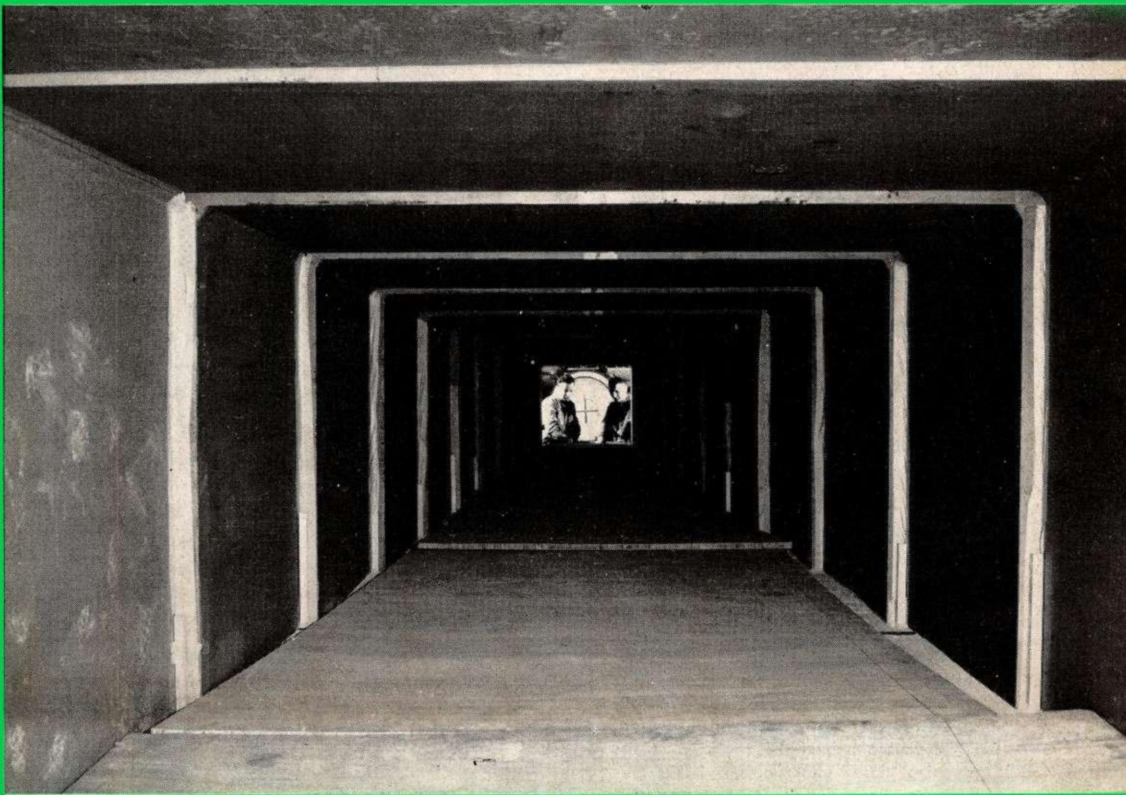
CERN COURIER



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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

The European Organization for Nuclear Research (CERN) came into being in 1954 as a co-operative enterprise among European governments in order to regain a first-rank position in nuclear science. At present it is supported by 13 Member States, with contributions according to their national revenues : Austria (1.92 %), Belgium (3.78), Denmark (2.05), Federal Republic of Germany (22.47), France (18.34), Greece (0.60), Italy (10.65), Netherlands (3.87), Norway (1.46), Spain (3.36), Sweden (4.18), Switzerland (3.15), United Kingdom (24.17).
Contributions for 1963 total 92.5 million Swiss francs.

The character and aims of the Organization are defined in its Convention as follows :

'The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.'

Last month at CERN

During the whole of March, work continued at the **proton synchrotron** on the numerous jobs arranged for the shut-down period. Of particular importance was the installation of the **fast-ejection system,** which will enable the beam of accelerated protons to be extracted from the machine, and the final setting up of apparatus for the forthcoming experiments with **neutrinos.**

The fast-ejection equipment consists essentially of two special magnets inside the vacuum system, together with beam-transport elements. A kicker magnet (the fast kicker or FK to the specialists), is rapidly brought into position round the beam at the end of the acceleration cycle and pulsed electrically so as to deflect the beam into a second magnet (the fast ejection magnet or FEM) which deflects it further, clear of the ring vacuum tube and main magnetic field of the machine and along a separate evacuated tube to the first of the small pulsed beam-transport magnets (fast magnets, FM, for bending and fast quadruples, FQ, for focusing). Apart from the mechanical installation of much of this equipment, all in careful alignment, considerable progress was made with connecting up the complex electrical units and the hydraulic systems for moving the magnets. Just outside the target area, in the South hall, a prefabricated room formerly used by the cloud-chamber team for processing and inspecting film was rapidly filled with racks of electronic equipment for controlling the pulsed beam-transport magnets and the neutrino horn. The horn, actually a means of providing an enhanced beam of pions, was placed in position in the target area early in the month. After the connexion of power and cooling-water supplies and tests to ensure that everything was working properly, work began on the installation of the shielding surrounding it, to absorb those pions and other secondary particles not directed towards the mouth of the horn.

For the fast-ejection equipment, various foundations, supports, pipework, etc. had already been installed during previous shut-downs, and the success of this policy was shown by the comparative ease with which the new parts were added. As a result, work was started on the installation of cables and junction boxes for the **slow ejection system,** which will also provide an external proton beam, but of different characteristics. A trial installation was made of the vacuum tank and transport mechanism for the slow ejection magnet (SEM) in the ring. This will considerably reduce the time required for the final installation.

Outside the tunnel, in the South hall, work started on the positioning of the complex array of large, heavy **spark chambers** for detecting neutrino interactions, together with liquid scintillation counters for controlling the triggering system. Also for this part of the neutrino experiments, a pair of large **magnet coils,** brought from Saclay and modified at CERN, were installed and tested. The vast amount of special **shielding,** including some 4600 tons of steel ingots as well as around 5000 tons of more conventional concrete shielding blocks, was nearly finished, and both the spark chambers and the **CERN 1-m heavy-liquid bubble chamber** disappeared from view.

Meanwhile, practically all the existing **beams** were dismantled. The 10-m **electrostatic separator** of the m_2 beam inside the South target area was removed for cleaning and maintenance, and later replaced. The expansion system of the **Saclay/École Polytechnique 81-cm liquid-hydrogen bubble chamber** was dismantled and moved out of the South hall to be overhauled and modified. The **CERN/E.T.H. Wilson cloud chamber** was removed from the North hall and taken for the time being to the new East experimental hall. Part of the new a_4 beam, to replace the a_3 beam that the chamber had been using, was put in place. In the **East hall,** which was put into service at the beginning of the month, the first beam, c_6, was about two-thirds completed. This beam, of protons scattered out of the accelerator, with energy equal to that of the circulating beam, is for experiments to determine the precise proportions in which different secondary particles are emitted when such a beam strikes

Contents

The cover photograph shows that not only massive shielding but also a large amount of air space is needed for experimenting with neutrinos. In this 'pion decay funnel', pions coming from the magnetic horn (just visible behind the two men at the opening) decay into muons and thus produce neutrinos. The funnel, erected during the recent shut-down of the CERN proton synchrotron, is 22 metres long and specially shaped to produce the maximum number of muon neutrinos (or neutrettos as they are sometimes called). Its cross-section varies from 1 m square at the beginning to 2.9 m x 1.8 m at the end. The walls are of steel plates 6 mm thick, and the funnel is completely surrounded by steel and concrete shielding to absorb all particles other than neutrinos.

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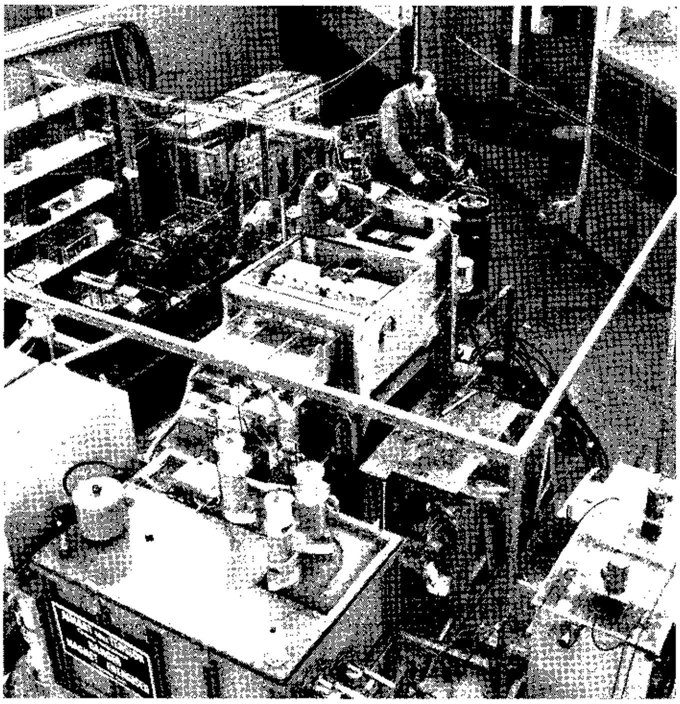

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Both the fast kicker magnet and the fast ejection magnet for extracting the proton beam were extensively tested by members of the NPA Division in the South hall extension before being installed in the synchrotron. Here Claude Scheffre is looking at the fast kicker in its opened vacuum box on the test stand, while Yves Favereau makes some adjustments to the hydraulic actuator. Further to the left is part of the test rig for the fast ejection magnet.

targets of various materials. These studies are vital to the success of the neutrino experiments, where it is more than ever important to know not only how many pions (and hence neutrinos) are being produced under any particular conditions, but also the exact nature of the 'background'.

The **accelerator ring magnets,** were relevelled, as previous measurements had shown that in the East target area the concrete ring on which the machine stands had sunk by some 2 to 3 mm (an amount regarded as considerable for such a machine), no doubt as a result of the extensive civil engineering work that had been carried out in that region. It also appeared that the ring beam had shrunk, reducing the diameter by some 5 mm (1 part in 40 000). As a result, it was decided to realign the whole accelerator, moving all the magnets, together with 'pick-up' stations, etc., back on to the original circle. Good progress was made with this work during the month. In addition, to facilitate the targeting system in the East area, magnet unit 60, in which the C-shaped yoke is towards the outside of the ring, was exchanged with unit 54, which has its yoke on the inside of the ring.

Also among the more noticeable changes being carried out during this shut-down was a rearrangement of the instrument racks in the **main control room.** At the same time, a glass partition was erected in one corner, providing a relatively quiet place where physicists can gather for discussion during experiments and from where they (and others) can have some idea of what is going on in the control room without actually having to enter it.

In the **Accelerator Research Division,** assembly was completed of the 2-MeV Van de Graaff injector for the electron storage-ring model, and a start was made on the preliminary tests. For the storage-ring itself, installation of control cabling was completed and the radio-frequency system finished. In order to be able to obtain the extremely high vacuum required in this apparatus, special methods of construction have been necessary and special heaters allow the whole ring-shaped vacuum chamber to be raised to a temperature of 300° C during the initial, and necessarily long, pumping period before the lowest pressure is reached. During March, this 'baking' and further vacuum tests were carried out, but the presence of a 'leak', small by normal standards but crucial in this kind of system, prevented pressures of much below 10^{-8} torr from being reached. (For comparison, this is still some 100 times lower than in the proton synchrotron and about one hundred thousand millionth of ordinary atmospheric pressure).

Towards the end of the month, the small mountain resort of St. Cergue, not far from Geneva, was the venue for three consecutive events, organized under the auspices of the CERN Emulsion Experiments Committee and bringing together **emulsion physicists** from many parts of the world.

Nuclear emulsions consist basically of the same material as that used on an ordinary photographic film, specially adapted to make them sensitive to nuclear particles. A charged particle passing through the emulsion sensitizes the grains of silver halide along its path, so that after development the track shows up as a row of black dots (which may merge into a continuous line). With special care to avoid distortion during development, accurate measurements on the length and direction of each track can be made using a microscope.

The **CERN Emulsion Experiments Committee,** with Prof. C.F. Powell of Bristol University as Chairman and J. Combe of the CERN Emulsion Group as Secretary, is one of the three Experiments Committees through which the experimental programme of CERN is organized, the others being the Track Chambers Committee (chairman : Prof. B.P. Gregory, Paris) and the Electronics Experiments Committee (chairman: Prof. P. Preiswerk, CERN). The recommendations of these three committees are co-ordinated by the Nuclear Physics Research Committee (of which the Director-general is chairman), which is responsible for recommending a detailed programme to the Directorate.

At present the Emulsion Experiments Committee is the most 'international' of the three. In addition to the members of the CERN Emulsion Group it consists of nineteen representatives from eleven Member states, together with six co-opted members from universities or research institutes in Berlin (East), Bombay, Dublin, Moscow, Rehovoth and Warsaw. One of the Committee's chief functions is to disseminate to all interested laboratories up-to-date information on the present and future facilities at CERN for experiments using nuclear emulsions. The other is to consider all proposals for such experiments and to decide on the best ones to submit to the Nuclear Physics Research Committee.

The first of the meetings at St. Cergue the **'CERN Emulsion Experiments Committee Spring Jamboree',** was designed to give first-hand information to the younger research workers who actually carry out most of the experiments, as distinct from the more senior scientists who attend the normal Committee meetings. On 18 and 19 March, about 60 of these physicists, from different European laboratories, met for a programme of

Physics using future accelerators

by L. VAN HOVE, Leader of the Theory Division

The first thing to be said in an article of this kind is that it is not really possible to discuss the kind of physics experiments that may be done with high-energy accelerators in the future, simply because it is impossible to predict what new discoveries are likely to be made. All that can be done is to consider what experiments physicists would like to do with such machines, assuming nothing unexpected happened between now and the date they came into operation.

In a sense it is easier to discuss this now than it was two years ago. This is because so much has been discovered recently and we can now make a longer list of attractive experiments to be carried out with future accelerators.

The two frontiers of physics

However, whether or not we can at this moment make a long list of future experiments, high-energy physics is bound to be important because it is one of the two great frontiers of physics. There is the frontier of small distances and the frontier of large distances. For small distances the frontier is at present around 10^{-14} cm, and for large distances it is about 10^{+27} cm. Between these two extremes, the world of physics is fairly well understood. We have good laws, with proper mathematical formulation, and these laws have good predictive power. At the frontiers themselves, however, we understand actually very little, and when we go below 10^{-14} cm or above 10^{27} cm everything is dark. We have no means, either experimentical or theoretical, of looking into these regions, but we are most anxious to explore this unkown territory. Unfortunately, however, this exploration is expensive. Towards small distances, very-high-energy accelerators are needed ; for large distances one requires very powerful instruments of observation, such as observatories in outer space.

In high-energy physics we are of course concerned with the very small distances, and the value of 10^{-14} cm is associated with the sort of energies produced by accelerators like the CERN proton synchrotron.

The unexpected richness of strong-interaction physics

In recent years the field of strong-interaction physics has proved to be of enormous interest because so many unexpected features have been found. First of all, the last two years have produced evidence for the existence of a great variety of 'particles'. Whether these objects are really particles or not is irrelevant ; they are states of matter with a considerable amount of stability and hence of individuality. Therefore, if the laws of physics at small distances are to be understood, these phenomena have to be studied.

At the present time very little is known about even the simplest properties of these particles. It will be a long time before all their quantum numbers are found, and even that knowledge would be far from an understanding of the role the particles play in dynamics, in collisions. Two years ago it was conventional to say that most secondary particles arising from inelastic collisions are pions. Now there are all these new particles. Are they all secondary particles or are some of them the genuine, first-generation secondaries produced in collisions ? Only when this is known, will it be possible to study properly the dynamics of inelastic collisions.

The second big surprise produced by the study of strongly interacting particles is the discovery of certain asymptotic energy variations for cross-sections at high energies, above about 5 GeV. This is the phenomenon of the 'shrinking diffraction peak' in proton scattering by protons, which has already given rise to many

Last month at CERN (cont.)

talks that included a comprehensive survey of the facilities provided by the CERN proton synchrotron and details of important emulsion experiments carried out in the past twelve months. G. L. Munday (CERN, PS Division) described all the improvements that have been made to the synchrotron over the last year or so, explained its present capabilities and modes of operation, and gave details of further developments. J. Sacton (Brussels) surveyed the studies on hyperfragments that are being carried out as a result of emulsion exposures in beams of negative kaons, H. Winzeler (Berne) discussed the various scattering experiments made using emulsions, and L. Hoffmann (CERN Emulsion Group) talked about the pulsed magnet at CERN for producing high magnetic fields. In addition, Prof. G.B. Zhdanov, of the Lebedev Institute in Moscow and one of the co-opted members of the Emulsion Experiments Committee, who attended the Jamboree as well as the Easter school that followed it, gave a survey of emulsion work carried out in Moscow.

The Jamboree was followed, from 20-27 March, by the **'1963 CERN Easter school for physicists using the nuclear-emulsion technique in conjunction with the CERN proton synchrotron and synchro-cyclotron'** — otherwise known as the Easter school. Nearly 60 students and more senior physicists attended for a course of lectures and discussion on theoretical and experimental aspects of the work currently of interest in high-energy nuclear physics.

Finally, from 28-30 March, there was an informal conference, the **'International conference on hyperfragments'**, bringing together physicists from a wider geographical area to discuss a more restricted subject.

Detailed reports on the last two meetings will be given in the May issue of CERN COURIER.

Friday, 29 March was another busy day for the electricians of the SB Division, when all the power transformers on site had to be readjusted to their

At the first meeting of the European Committee on Future Accelerators, held last January at CERN (see CERN COURIER, vol. 3, no. 2, p. 18), Prof. L. Van Hove presented a paper with the rather impressive title of 'The physics that could be done with future high-energy accelerators as it appears in January 1963'. This is a revised version of that talk, in which Prof. Van Hove discusses the present frontiers of high-energy physics and considers how more-powerful accelerators would help to solve outstanding problems. He concludes with a discussion of the 'long-range' view – the question why it is desirable, or even necessary, to investigate these problems even when the means to do so become so expensive.

experimental and theoretical considerations and developments. It is to be presumed that this whole field of asymptotic energy variations is going to be with us for a long time. It will be one of the great sources of information and it may dominate the picture for some time to come — most likely, even when the next generation of accelerators is in operation. For example, it seems to be true that the proton-proton diffraction scattering with its slow shrinking is the 'shadow' of the inelastic collisions. What is done at present is just to see how the shadow changes. But nobody studying optics would investigate the precise shape of shadows without wondering how they were produced. One day the elementary-particle physicist will look not only at shadows but also at the absorption that produces them, and therefore he will again study inelastic collisions, trying to see what it is in the absorption process that gives rise to slow modifications of the shadow scattering. This brings us again to the long list of strongly-interacting particles, because it is only possible to study slow energy variations in inelastic collisions if the true secondaries are known. The growing list of fundamental particles and the energy variation of scattering patterns thus belong to the same general class of problem.

Two years ago it seemed that in the field of high-energy collisions of strongly interacting particles two things were easily explained on the basis of intuitive concepts, and therefore not terribly exciting. These were diffraction and the so-called 'pionization', that is, the production of pions with small transverse momenta. Now, this hope seems to have vanished. Pionization and diffraction are just as much a puzzle as the rest of strong-interaction physics. Intuitive concepts have proved insufficient and experimentalists will have to study both problems extensively before the empirical facts can be described and understood properly. The concepts used now are just about good enough to allow a crude description of some of the experimental facts that have been found, but none of them has predictive power at all.

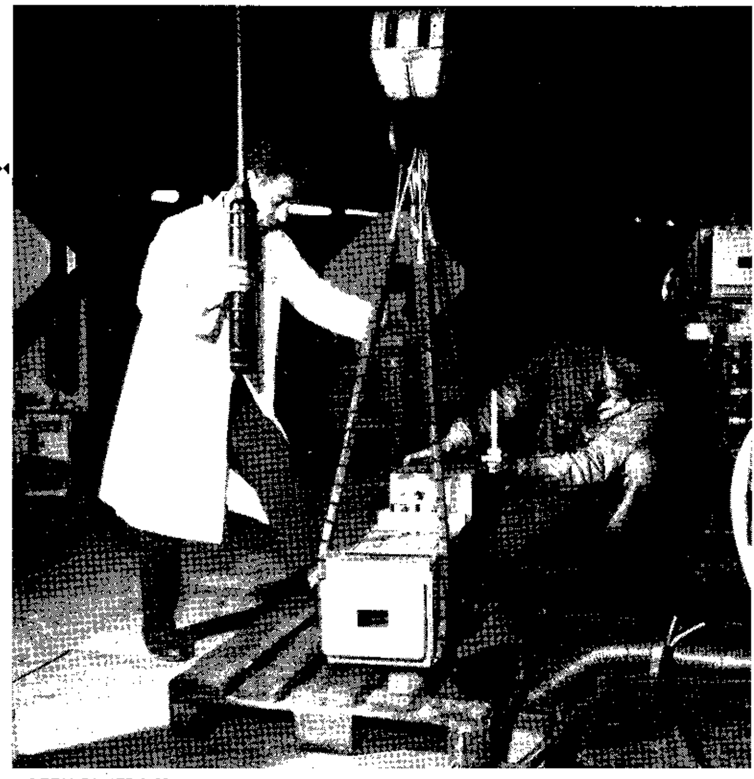
There is much scope for new concepts, new ways of analysing experiments, and new theories. These, however, are only likely to arise through experimental studies. For these studies one needs much higher energies, for exploring collisions which produce many particles and to investigate phenomena that vary slowly with energy. Very good intensities are also needed because the effects of interest are not dramatic and require refined and accurate work. A lot of flexibility in experimentation is also required, in particular the possibility of studying as many types of collision as possible : proton-proton, neutron-proton, pion-proton, kaon-proton, antiproton-proton, and many more if at all possible. Such studies require good, intense beams of high-energy particles.

The physics of leptons

In the field of leptons, that is electrons, muons and neutrinos, as well as their interactions, which are the electromagnetic and the weak interactions, the last two years has not given any unexpected surprises. The discovery of the second neutrino, fundamental as it is, was not really a surprise but the confirmation of a bold theoretical prediction which a number of people had made on the basis of previously known facts. This lack of surprise is an indication that our understanding of this part of physics is much better, so that useful, realistic theoretical discussions are possible before experiments are done.

former settings as a result of the **restoration of the electricity supply voltage** to its normal level. Although the shortage of electricity, noted in 'Last month at CERN' in the March issue of *CERN COURIER*, had been expected to last until about Easter, extra heavy rain during the last week of March raised the water levels in the reservoirs supplying the hydro-electric stations to such an extent that precautions like the reduction of the supply voltage were no longer necessary.

The appearance of the landing outside the Auditorium, in the Administration building, has been enlivened by the arrival of an animated **model of the proton synchrotron** and its experimental



Roger Gerst, NPA Division (left) and Gabriel Crochat, of SB Division, prepare to lift one of the pulsed bending magnets for the ejected proton beam into position on the steel girder just visible to the right of the picture. Another of the magnets can be seen already in place. Their small size (the aperture is 65 mm x 40 mm) can perhaps be judged by comparing them with the normal quadrupole focusing magnets in the background and to the left.

CERN/PI 175.3.63

The most important task for a future programme of lepton physics is the search for deviations from the presently accepted theories of quantum electro-dynamics and weak interactions. Both kinds of study are in progress now and will continue for quite a while. The extension of this sort of work will carry us necessarily to increasing momentum transfers, especially in electro-dynamics. It will be necessary to do electron collisions (electron-electron, and electron-proton) and muon-proton collisions at increasing energies and angles, in order to explore the higher momentum transfers, which unfortunately have very small cross-sections.

The same general course will probably be followed with neutrino physics. Electron-nucleon scattering will be replaced by neutrino-nucleon collisions, and the main difficulty will be with the small cross-sections. Neutrino physics again has a possible fundamental discovery on the programme : the intermediate boson, which, if it exists, would fit well within the framework of current thinking. This type of work will no doubt be going on next year, the year after, and probably still in 1968 or 1970, although in the meantime unexpected things may come in addition — perhaps related to the strange particles, the weak decays of which are so puzzling.

The search for deviations from accepted theoretical views may possibly lead to the answer to an outstanding question first asked long ago. This is the puzzle of the two electrons, the difference between electron and muon. It is not clear whether higher energy is necessarily needed in this case. Maybe measurement of the mass of the neutretto, the neutrino of the muon, will produce a crucial advance. However, it may also be that, to obtain new information on the electron-muon puzzle, neutrino energies of several hundred GeV would be required, which would be very expensive.

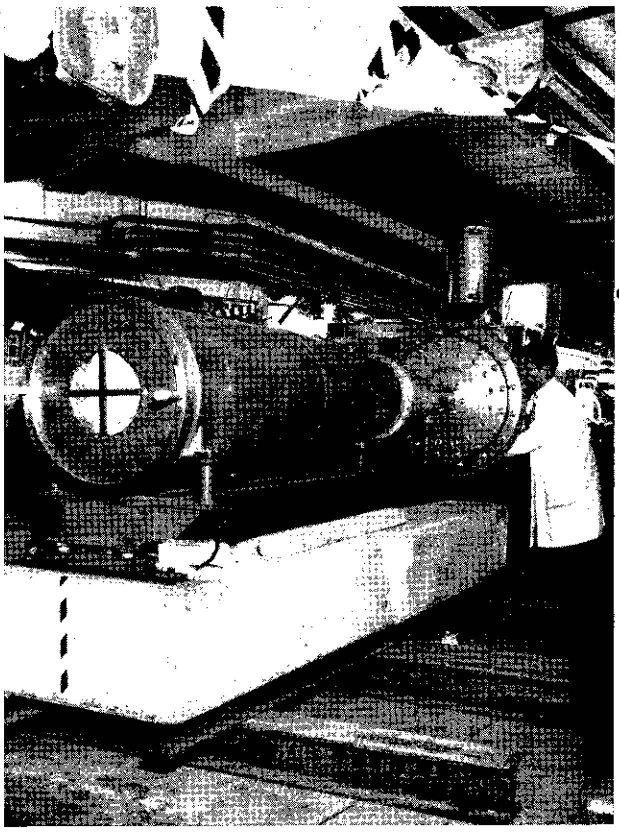
High-precision work in energy regions already explored

Especially in the field of weak interactions, where cross-sections decrease rapidly as the energy is increased, not only higher energy is required but also higher intensities. This raises the more general question of high-intensity accelerators in the energy regions already explored, that is, of highly refined work in the energy regions which have already been studied at a lower level of precision. Are very high intensities at moderate energies going to be as good a source of new knowledge as higher energies at conventional intensities ? If a choice has to be made between the two, the answer would appear to be 'no'. On the other hand it is better to regard high intensities at moderate energies as a complementary field of study, and considerable attention should be paid to the necessity of giving it the right emphasis. Undoubtedly, however, the unexplored region of very high energies is the most likely source of important new discoveries.

The long-range view

So far, this discussion has been almost entirely on the problems of high-energy physics and the means needed for their investigation. However, it may well be asked why these problems are of interest at all. What, taking the long-range view, is the general significance of high-energy physics ?

In discussing the general significance of physics as a whole it is convenient to distinguish the 'practical' significance and what might be called its 'philosophical' or 'epistemological' significance, that is its significance for human knowledge in general. Consider, for instance, electromagnetism, the phenomena of electricity and magnetism. The practical significance is clear. Understanding of this branch of physics is very closely connected with the understanding and controlling of electricity and of electromagnetic radiation in all forms : radio-waves, light, radar. The practical applications are only so complete and diversified because the basic understanding is so good. As for the epistemological significance of electromagnetism, its main contribution has been the theory of relativity. Maxwell's equations probably did not excite the layman very much, but certainly relativity has been a striking development for philosophy and human knowledge in



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Last month at CERN (cont.)

The magnetic (or neutrino) horn was one of the first pieces of new equipment to be placed in position near the synchrotron during the shut-down. Seen here behind the horn is Roger Gerst, working on the pulsed beam-transport system. This conducts the protons ejected from the accelerator to the target in the throat of the horn, where they produce pions.

areas. Coloured lights on the model, operated by labelled push-buttons, locate the major parts of the accelerator and associated experimental equipment, and coloured-light sequences indicate the acceleration process with the production and detection of secondary beams. The model is particularly useful for explaining the functions of the accelerator to large groups of people, particularly since most visitors to the laboratory come on Saturdays, when the synchrotron is normally in operation and therefore inaccessible.

general. Yet there could have been no relativity without electromagnetism. Relativity was born from the clash between Maxwell and Newton, and both were necessary for Einstein.

Then there is the example of atomic physics. The practical consequences of understanding atomic and molecular structure through quantum theory are obvious. It has led to the detailed understanding and controlling of all the forces at the atomic level, that is of all the forces that dominate chemistry, solid-state physics, etc. The epistemological consequences arise from quantum theory itself, particularly statistical interpretation and the concept of complementarity, which are striking examples of how important the implications of physics can be in philosophy.

In the field of elementary-particle and high-energy physics, included in the broader one of nuclear physics, the question of general significance is largely for the future to determine. On the practical side, nuclear forces (those forces which are believed to be caused by mesons) have already found very spectacular applications, but these resemble to some extent the practical uses of chemistry before atomic and molecular forces were understood. Chemical forces, the energies of chemical reactions, were used extensively by humanity long before the real structure and the conceptual world of atomic and molecular phenomena were really understood. In a certain sense it is true that nuclear forces are known fairly well. It is known how nuclei stick together, and they are used in all kinds of practical ways. But nobody at present claims to understand nuclear forces. They can only be described by somebody or other's potential, which is not only ugly and complicated but almost completely misunderstood. It has also been learnt that the understanding of these forces will not come from low-energy nuclear physics, but will only be reached by looking deeper into the properties of fundamental particles, towards higher energies in other words.

The Yukawa programme for explaining nuclear forces in terms of particles has still not been carried out, and this is hardly surprising when it is realized that it was tried for 25 years with one meson whereas three others with an equal right to participate have now been found. It seems that in the field of nuclear physics something analogous to the understanding of chemical forces through atomic physics and quantum theory will arise. New applications of nuclear forces, more refined and better under control, can therefore be expected when the true nature of these forces is understood, in the sense of an accurate, reliable and rational description with full predictive power.

When this time comes there will probably also be fundamental consequences on the epistemological level. At the moment the fundamental discoveries and concepts of high-energy physics appear to be of interest mainly to physicists. Consider the existence of antimatter, the violation of parity, the symmetry between matter and antimatter, the existence of many strongly interacting particles, the existence of fundamental variables outside space and time (like baryon number, lepton number and isospin), the hierarchy of interactions (strong, electromagnetic, weak), and the strangely parallel one of symmetry properties. Although these are overwhelmingly important to the specialist, none of them seem to hold much interest for the layman. The same is probably true for unsolved questions like the place of gravitation in the hierarchy of interactions, or the possibility that this hierarchy might cease to exist at high energies.

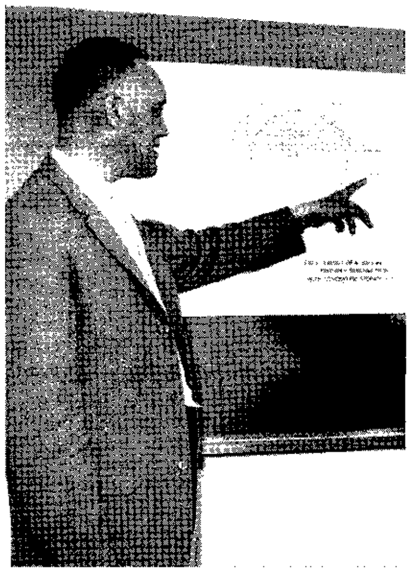
However, at the moment, physicists have discovered a forest or particles and interactions. They are looking from a distance very roughly at what it contains and there is little point in trying to predict what will emerge at the basic level of general scientific concepts and human understanding. The very fact that the variety of unexpected findings is so puzzling, and that so much has appeared which fits so poorly into the present framework of thought, is a promise that new fundamental discoveries may very well be in store at the end of a long process of elucidation. Through these discoveries, the nature of the basic forces in this field of physics may eventually be grasped. In so doing, new consequences may arise, which may be as significant as the two mentioned above, relativity and complementarity. It should be remembered that both of these arose at the end of many years of very thorough experimental work, at a detailed level where the layman could find little intellectual excitement. The study of nuclear physics has now reached such a detailed level. A look back to the past produces an extremely strong motivation for the vigorous continuation and extension of this work ●

One of the visitors to CERN in March was Mr. **A. Meller-Conrad**, Plenipotentiary and Permanent Representative of Poland to the European Office of the United Nations Organization. During his visit, on 22 March, he met a number of Polish scientists working in various Divisions at CERN.

Among the new **Fellows of the Royal Society** elected at a meeting on 21 March were Dr. **J.B. Adams** and Prof. **E.H.S. Burhop.** Dr. Adams, formerly head of the PS Division and then Director-general of CERN, and now director of the Culham Laboratory of the United Kingdom Atomic Energy Authority, was elected as one 'distinguished for his contributions to the design and construction of the 25-GeV proton synchrotron at the European Centre *(sic)* for Nuclear Research'. Prof. Burhop, professor of physics at University College, London, 'distinguished for his contributions to experimental and theoretical atomic and nuclear physics, particularly to the Auger effect and atomic collision processes', is spending this year at CERN with the study group on future accelerators in the Accelerator Research Division. Prof. **P.T. Matthews,** professor of theoretical physics at the Imperial College of Science and Technology, London, 'distinguished for his contributions to quantum field theory and the theory of elementary particles', who was also elected, is known to many people at CERN and spent some weeks in the Theory Division last summer.

After the Nobel Prize, Fellowship of the Royal Society is regarded as the highest scientific honour a scientist can hope for in the United Kingdom. The Society was formally established in 1660 and at present no more than 25 new Fellows, from all branches of science, may be elected each year ●

Cornelis ZILVERSCHOON
Kjell JOHNSEN
Arnold SCHOCH



CERN/PI 31.5.63

C.J. Zilverschoon (left), K. Johnsen and A.
proton synchrotron surrounded by a pair of

Many people, and not only those outside CERN, will be surprised to learn that one of the Organization's twelve Divisions is run jointly by three men who take it in turns to assume the official title and functions of Division Leader. This is, however, true of the Accelerator Research Division, where K. Johnsen, having replaced A. Schoch in January 1962, has this year handed on the title to C.J. Zilverschoon.

This state of affairs dates back to the time when, following the successful completion and operation of the proton synchrotron, many of the senior physicists and engineers who had built it migrated into the Accelerator Research group (as it then was) of the PS Division, and began to turn their eyes again towards the future.

At first the group also included M. G. N. Hine, now Directorate Member for Applied Physics, and P. Lapostolle, now Leader of the MSC Division, but by the time the AR Division was constituted at the beginning of 1961 the senior staff consisted of H.G. Hereward, K. Johnsen, A. Schoch and C. J. Zilverschoon. Already they were thinking of new, bigger projects, and it seemed to them that their responsibilities should be, more than in any other Division, towards CERN as a whole rather than just to the Division itself. Thus it was agreed that all decisions on policy — which projects to recommend, which fields to explore, etc. — would be taken jointly by all four acting together. Since, however, the normal day-to-day administrative responsibilities of a Division Leader cannot easily be divided among three or four people, it was decided at the same time that this post would be held for a year by each in turn. A strong argument in favour of such a rotation was also the fact that none of them would be faced with an inescapable decision to give up most of his time to routine administration rather than to the more interesting scientific work.

Thus it was that at the end of 1961, A. Schoch, who in fact had been head of the original AR group, handed over to K. Johnsen, who has in turn passed on the duties of Division Leader to C.J. Zilverschoon. H. G. Hereward, meanwhile, has returned temporarily to the PS Division, to deal with problems of development there.

Cornelis J. Zilverschoon, Leader of the AR Division for the year 1963, was born in Dordrecht, in the Netherlands, in 1923. Following the usual primary and secondary education, he found the Universities closed to him, as a result of the German occupation, so instead he attended a technical college (Middelbare Technische School) to study electrical engineering. In 1945, however, he was able to enter the University of Delft, where he turned his attention to physics, which, as he says, 'had then become more fashionable'. After obtaining his degree, he moved to Amsterdam, in 1949, where he worked in the Laboratory for Mass Spectrography (Laboratorium voor Massaspecktrografie) on the construction of an electromagnetic isotope separator. This led also to his Doctorate, early in 1954.

His supervisor, the Director of the laboratory, was the late Prof. C. J. Bakker. CERN was in process of being formed, Prof. Bakker had been involved with its work from 1952 onwards, and they had discussed its progress from time to time. The natural outcome of this was the suggestion that Dr. Zilverschoon should join the group responsible for the synchro-cyclotron in the new organization. At the same time, however, plans were being made in Argentina for the construction of an isotope separator, to complement a newly acquired cyclotron in Buenos Aires, and Dr. Zilverschoon was asked to go there to build it — involving a stay of from three to six years.

He decided that he would rather remain in Europe, but nevertheless agreed to spend about three months in Buenos Aires, where he set up a group to build the separator. While he was still there, it was suggested that the join CERN's Proton Synchrotron Division rather than the Synchro-cyclotron, with the result that in May 1954 he came to Geneva as Head of the PS Mechanical Engineering group. His main concern was the drawing office, which, like many other parts of CERN, was housed in the Institute of Physics in town until 1957, but he was also involved extensively in making contacts, and often placing contracts, with European industrial concerns.

choch (right) discuss the layout of a 300-GeV storage rings for colliding-beam experiments !

An account of the three senior scientists of the Accelerator Research Division at CERN and a summary of the work of the Division.

Accelerator Research Division

From 1958 onwards he was occupied with the installation of the accelerator, and then at the end of 1959, when everything was operating successfully, he transferred to the Accelerator Research group, as described earlier.

Kjell Johnsen comes from Bergen, in Norway, where he was born in 1921. He studied electrical engineering at the Technical University of Norway, Trondheim, and then, after one year as an assistant at the University, joined the Chr. Michelsens Institute at Bergen. Work on accelerators had become traditional at this Institute, and he began a study there of linear accelerators. For rather more than a year, in 1950-51, he visited Imperial College, in London, where he worked under Dr. D. Gabor, mainly on accelerator theory but also on plasma physics. These studies eventually led to his Doctorate, from the Technical University of Norway, in 1954.

Before then, however, in July 1952, Kjell Johnsen had become one of the first CERN staff members. Still at the Chr. Michelsens Institute, but 'on loan' to CERN, he joined the proton synchrotron study group of the embryo organization, working under O. Dahl, one of the senior scientists at the Institute, who had been appointed leader of the group on a part-time basis. At that time the early design work for CERN's 'big machine' was spread among many established European laboratories, and it was not until the end of 1953 that Kjell Johnsen came to Geneva. At first he worked on the theory of the alternating gradient accelerator — then still a relatively new and untried idea — but later he concentrated again on linear-accelerator problems, joining the Linac group of the PS Division (as it had by then become), under H. G. Hereward, in 1954.

Three years later, he returned to Trondheim, as Professor of Theoretical Electrical Engineering at the Technical University of Norway, where he stayed until 1959. Returning then to Geneva, he joined the Accelerator Research group, which was engaged mainly on problems arising from the running-in of the newly completed synchrotron. This work, as is well known, proved less troublesome than many people had expected, and soon he was able to think more of accelerator research as such, and particularly of plans for the electron storage-ring model, which is now itself being put into operation. He is now leading the group making the design studies for possible future accelerator projects.

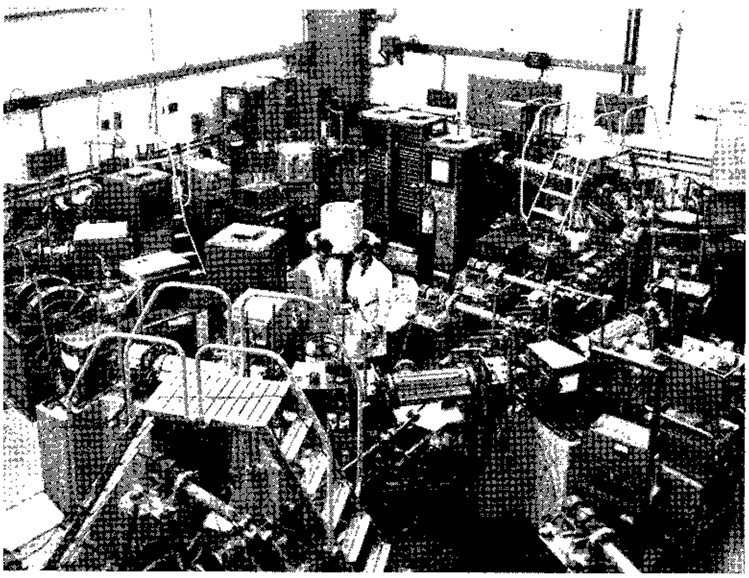
Arnold Schoch was born in Stuttgart, Germany, in 1911. After leaving school, he studied physics at the Technical University (Technische Hochschule) of Stuttgart, graduating in 1933, and then went to the University of Berlin. There he was awarded his Doctorate, in 1936, for a thesis dealing with a problem of elastic waves.

He then joined a research laboratory attached to the Technical University of Berlin, where he worked in the field of accoustics on applied and theoretical problems of wave propagation. During the war he became concerned with the growing subject of ultrasonics, largely as applied to the testing of materials and the study of phenomena such as cavitation. Afterwards, he went to the University of Göttingen, where he carried out further work, but of a more academic nature, on problems of wave propagation in solids and liquids.

Then, in 1950, he accepted an invitation to take up a post as 'Dozent', for theoretical physics, in the University of Heidelberg. While there, he was asked if he would like to join CERN. This seemed a good opportunity to combine his backgrounds of theoretical and experimental physics, and so early in 1954 he arrived in Geneva to work in the Proton Synchrotron group on the theory of particle orbits — once again involving oscillations, but of a rather different kind to those that had occupied him earlier in the fields of ultrasonics and accoustics in general.

Later, as the problems of the synchrotron were resolved, he took charge of the Accelerator Research group, which, as described above, became the AR Division in 1961.

The work of the Accelerator Research Division at present falls into four main groups : radiofrequency



CERN/PI 44.2.63

A general view of the 2-MeV electron storage-ring model during the last stages of assembly. The injection line for the electrons enters at the bottom of the picture (under the ladder) and meets the ring at the back, to the right. Near there, Joseph Karouanton (S.G.T.E., Paris) (inside the ring), **and Marcel Bernasconi (AR Division) are seen testing for leaks in the vacuum system. In white coats are Mervin Barnes** (left) **and Bonny Bruggeman (AR Division), considering the reading shown by one of the vacuum gauges.**

separators, under B. Montague ; the electron storage-ring model, under M. J. Pentz ; 'general studies', under A. Schoch ; and the study group on new accelerators, under K. Johnsen.

The radiofrequency (r. f.) separators are intended to provide beams of separated antiprotons and kaons at the PS, with momenta eventually up to about 20 GeV/c, this momentum limit being set by the number of particles available rather than by the possibilities of separation. To obtain the separated beam, particles are first directed through a 'deflector' cavity, where they are deflected by an electric field whose value is modulated at a frequency around 3000 Mc/s (MHz). At any instant of time, the deflection will be the same for all particles of the same momentum, whatever their mass. After a certain distance, the particles pass through a second, and then a third cavity, the 'analyser', where they are further deflected. However, since heavier particles travel slower (for the same momentum), particles of different masses will arrive at these two further cavities at different times. Hence, if the value of the electric field is fluctuating in the same way in all three cavities, particles of different masses will experience different values of the field in the second and third cavities and will be deflected by different amounts. By proper timing, and appropriate beam optics, it is possible to ensure that a particular fraction of the beam-pipe aperture is occupied by particles of a single type. The other particles can then be eliminated by blocking off the rest of the aperture with a beam stopper. It is hoped to have the first two cavities ready later this year.

The storage-ring model is the only one of its type in the world. It has been built for investigating on a small scale some of the more fundamental problems that will have to be faced if large proton storage rings are used at the PS. A primary problem is the maintenance of an exceedingly good vacuum, with a residual pressure some 10 000 times less than in the PS, and special techniques — sealing rings made from gold, complete electropolishing of the interior of the ring-shaped vacuum chamber, baking of the whole ring to 300° C, etc. — are being tested on the model. Then there are many problems in the process by which pulse after pulse of particles can be brought into the ring and 'stacked' in such a way that circulating currents of up to several ampères (of protons in the big rings) can be obtained and controlled for colliding-beam experiments. These problems, too, will be studied in the model.

In addition, the group is looking forward to using the electron storage ring as a more general-purpose experimental tool, to carry out detailed studies on the fundamental operations of particle accelerators like the PS — studies which the physics research programmes of existing accelerators never allow time and equipment for.

The general-studies group is concerned with exploratory work, related to accelerators and their instrumentation, falling outside the specific objectives of the other groups. As an example, fundamental investigations into the basic processes in spark chambers may be mentioned — a study which was started some time before physicists at CERN began to use this method of particle detection to any extent.

The study group on new accelerators, probably the most important part of the Division's responsibilities at this time, was set up officially at the beginning of 1962, although work had been going on for about twelve months before that. Its main aim has been to investigate the technical details of possible new projects, and its efforts have been concentrated on two :

a) a proton synchrotron in the range 150-300 GeV ;
b) a set of storage rings for the present CERN proton synchrotron.

A synchrotron of 300 GeV would have a circumference of about 7.5 km, of which the main magnet would occupy 70 %. For lower design energy the circumference becomes correspondingly smaller. As injector it would very likely have another small synchrotron which in turn would be supplied with protons from a linear accelerator. The problem of where in Europe it would be possible to build such a machine is also being studied, but it is expected that a considerable time will be needed to settle this issue.

A set of storage rings for the CERN PS would have to be constructed in the immediate neighbourhood of that accelerator, and the most likely situation is just North of the PS, on the piece of land recently offered to CERN by France (the protons having to cross the present frontier to enter the storage rings). Two distorted concentric magnet rings, each with a diameter of about 270 m, would be used, the distortions being arranged so that the rings would cross each other in 8 places. Proton beams circulating in each ring could be made to collide at these crossing points.

Since the beginning of this year, the study group has been engaged on providing data for the committee of European physicists which (as reported on p. 18 of the February issue) was set up to make recommendations on a future high-energy programme for Europe ●

BOOKS

Radioactives substances (New York, Philosophical Library, Inc., 1961 ; $ 2.75) is 'a translation from the French of the classical thesis presented to the Faculty of Science in Paris by the distinguished Nobel Prize winner Marie Curie'. Unfortunately (and this seems to be a common fault with such books from this publishing house), no indication is given of when the thesis was presented. We are told in an introduction that Mme Curie was awarded the Nobel Prize in 1911, also that she was born in Warsaw in 1867, entered the Sorbonne in Paris, in 1891, discovered radium in 1904 (actually 1898, she obtained separated salts in 1902), and died of the effects of its radiation in 1934. But the vital date, which would enable us to put into historical perspective what Marie Curie herself describes as 'an inclusive survey of the actual position', is missing.

The account itself is fascinating. One is struck straight away by its simplicity and directness, so different from much present-day writing. — 'We shall say that uranium, thorium and their compounds emit *Becquerel rays*. I have called *radioactive* those substances which generate emissions of this nature. This name has since been adopted generally'. There is thus little difficulty in following this story of the ideas and the work that led to the separation of the previously unknown substances polonium and radium, and the many investigations of the properties of the new atomic radiations. At the end, Marie Curie's particular contributions are pointed out, but in the main body of the thesis the general pattern of ideas and discoveries of that time is unfolded, with the names of many other scientists, some famous, others long since forgotten.

There is a foretaste of large-scale research to come, with laboratory chemical methods applied on a factory scale to enable a hundred milligrams or so of radium to be extracted from several thousand kilograms of uranium-ore residues. At the same time, their methods, both chemical and physical, were simple, although the care with which they were applied by Mme Curie and her collaborators is evident. That their enthusiasm carried them away, and made them oblivious to probable dangers, is clear from her descriptions of the effects of the radiation — paper became brittle, scorched, and finally full of holes ; 'In one experiment, M. Curie caused a relatively weak radioactive product to act upon his arm for ten hours. The redness appeared immediately, and later a wound was caused which took four months to heal' ; experiments are mentioned in which animals died in a few days. Yet she complains only that the ionization of the air in her laboratory, caused by the general 'background' of radiation and radioactive dust particles, destroyed the electrical insulation of their measuring apparatus.

In one other sense was Mme Curie blind, and it is very revealing to see how subject these scientists were to the prevailing beliefs, which included the immutability of the atom. She describes many different experiments on what she called 'induced radioactivity', all of which show quite clearly to a modern mind that her radium was emitting a gas that was itself radioactive. Yet she could write : 'Mr Rutherford suggests that radioactive bodies generate an emanation or gaseous material which carries the radioactivity. In the opinion of M. Curie and myself, the generation of a gas by radium is a supposition which is not so far justified. We consider the emanation as radioactive energy stored up in the gas in a form hitherto unknown'. Their quantitative measurements of this time were well on the way to discovering the laws of radioactive decay, but to them radioactivity appears to have been something like the 'caloric' of an earlier generation. Certainly it was 'a profound and wonderful enigma'.

The translation seems good, apart from one or two glaring faults, but it must be said that the printing, including the number of errors, is not really worthy of the subject matter. The price seems high for such a publication, which is a pity, because the thesis is well worth reading.

A.G.H.

Teilchenbeschleuniger (Particle accelerators), by Rudolf Kollath (Braunschweig, Friedr. Vieweg & Sohn, 2nd edition, 1962 ; DM 42.—).

The appearance on the market of a new edition of this book is a sure indication that the first edition, now eight-years' old, has been a success with those for whom it was intended by its author, namely students and others interested in the problems of particle accelerators as a sideline to their main field of interest.

A glance at the list of collaborators who have written for this new edition shows also that Prof. Kollath, the editor and chief author, has been able to enlist the support of those who are working at the most advanced centres of accelerator theory and technique. The reader is thus assured of finding the most up-to-date information on the various methods that exist today for the acceleration of elementary particles. Moreover, despite comprehensive descriptions of the various types of accelerator and their corresponding problems, a serious attempt has been made to avoid over-long and complicated mathematical treatments. In style, the book is pleasant to read, and those who want to penetrate more deeply into the subject matter are led easily to the necessary specialized literature. It is, in fact, of great advantage to find a very complete bibliography at the end of the book.

The difficult task of finding German equivalents for English terms that have become well established in the international vocabulary of accelerator theory has been overcome skilfully (though this has not prevented the creation of 'Runzelröhre' for 'disc-loaded waveguide').

To sum up, the book can be recommended to the German-speaking reader who wants to become acquainted with the problems arising in the theory and practice of particle accelerators, and it can safely be used as a quick reference source by the more experienced reader.

F. Ferger

The Pergamon Press, Oxford, which is well known for its publications concerning nuclear physics and for its large collection entitled **Progress in Nuclear Energy,** has brought out a new volume devoted to **Law and Administration** (Volume III, 1962, edited by Jerry Weinstein ; £7).

In view of the extremely rapid development of nuclear science, the Pergamon Press has catalogued the subjects covered, and the publications in the series *Progress in Nuclear Energy* have been subdivided into various groups.

The latest volume mentions the following twelve groups:

I	Physics and Mathematics
II	Reactors
III	Process Chemistry
IV	Technology and Engineering
V	Metallurgy and Fuels
VI	Biological Sciences
VII	Medical Science
VIII	Economics
IX	Analytical Chemistry
X	Law and Administration
XI	Plasma Physics and Thermonuclear Research
XII	Health Physics

The editor of the first two volumes of *Law and Administration* is Herbert Marks of Washington, D. C., a lawyer and legal adviser to various associations concerned with nuclear questions, whereas the editor of Volume III, the latest, is Jerry Weinstein, a lawyer educated in England, who occupies the post of 'Counsellor in charge of legal questions' at the O.E.C.D. in Paris.

The collection *Law and Administration* consists of two main elements. Part of it is devoted to the publication of the text of agreements and laws relating to nuclear subjects (Volume II and the annex to Volume III). Since the circles consulted seem to be on good terms with the American Administration, a number of internal US executive regulations have been included. All laws are quoted in English: the reader is therefore dependent on translations when the laws concerned are not those of an English-speaking country.

On the other hand, the greater part of *Law and Administration* is a collection of articles by various distinguished authors on the legal questions posed by nuclear development. There can be no question that the choice made by the editors is a wise one.

Volumes I and III contain numerous articles showing the many different aspects of the problems, comparing the legislation of different countries and discussing international agreements.

Personal legal theories are presented and defended with verve, which is perfectly natural. The books are intended both to give information and stimulate discussion. The questions raised are handled by writers whose professional work places them at the hub of such problems: it is a pleasure to note that the trend of atomic law is to abolish or attenuate the effects of geographical frontiers.

Frédéric Lehmann

Reactor Safeguards, by Charles R. Russel (Oxford, Pergamon Press, 1962 ; 80 s.), is a recent volume in the series of **International Monographs on Nuclear Energy** produced by Pergamon Press.

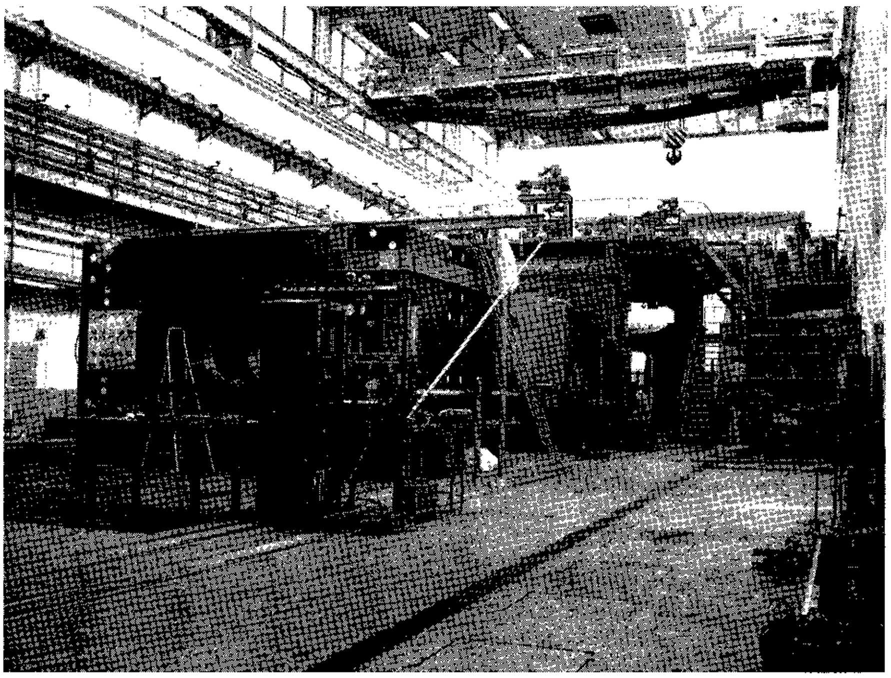
Safe operation of nuclear reactors has been a subject of concern ever since the first pile was successfully operated in Chicago in 1942. From that time on, attention to safety problems has gone hand in hand with the development of nuclear energy, and their study and solution today form a major part of the whole atomic-energy programme.

This book deals primarily with the way in which reactor safeguards have been developed in the United States, how the problems were studied, and how they were solved for existing reactors in the light of research and experience. Sufficient basic information on radioactivity and reactor physics is given to enable the safety problems to be judged effectively, and there is an impressive review of artificial reactor 'accidents' carried out to gain knowledge on the precautions that should be taken.

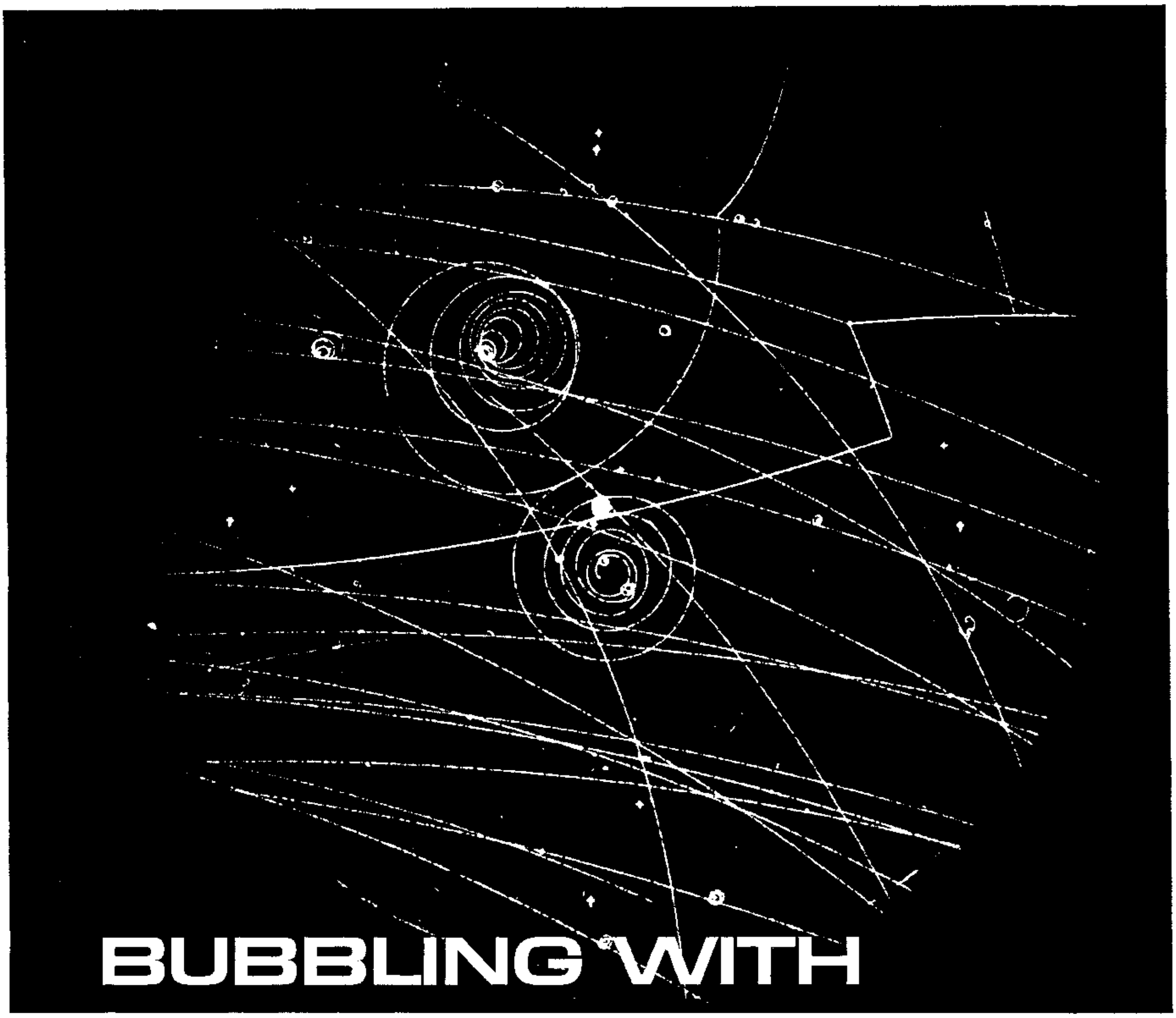
A large part of the book is devoted to detailed descriptions of every accident in the United States that has been accompanied by a significant release of nuclear energy and radiation. These make very interesting reading. It should be pointed out, however, that the book is not particularly suited as a reference book for reactor, or other, safety procedures ●

J. Baarli

* * *



At the beginning of March work was well under way again around the magnet of the British national hydrogen bubble chamber, in preparation for the arrival of the chamber itself and other associated equipment. This picture of part of the East bubble-chamber building shows the British chamber in front of the CERN 2-m bubble chamber, on which also steady progress is being made. In the right background is the nearly completed hydrogen refrigeration plant for the CERN chamber.



BUBBLING WITH NEW IDEAS AT -270°C

Tracks of high energy particles in a bubble chamber.

The National Institute for Research in Nuclear Science has asked British Oxygen to design and build a refrigerator for use with a liquid helium bubble chamber. With this the institute will be investigating the paths and interactions of high energy particles.

The refrigerator, believed to be the largest of its kind in the world, will operate continuously at —269° to —270°C for periods of 30 days with an accuracy of ±0·05°. It will provide 80 watts refrigerating capacity at these temperatures, plus another 500 watts at —193°C.

To meet this exacting and unique specification, the refrigerator is being specially designed by British Oxygen's Scientific Division. Many new techniques are being employed such as expansion turbines running on helium gas lubricated bearings at up to 350,000 r.p.m., and pipe-work lagged with reflecting layers of aluminium interleaved with glass fibre.

The plant will be constructed by British Oxygen's Engineering Division at Edmonton and will be installed and operating in 1964.

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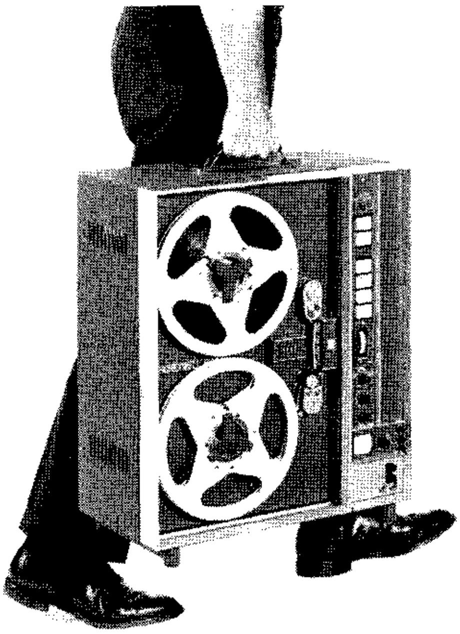

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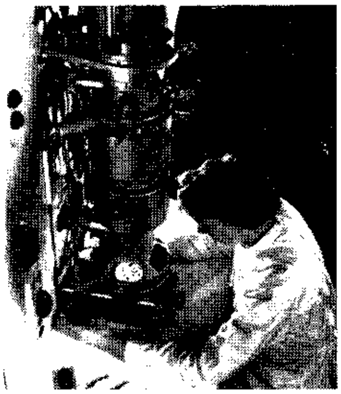

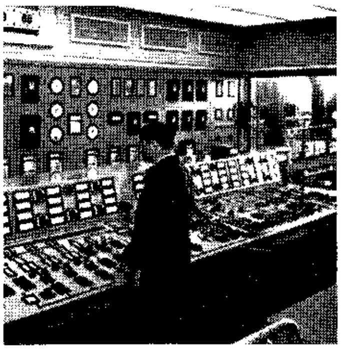

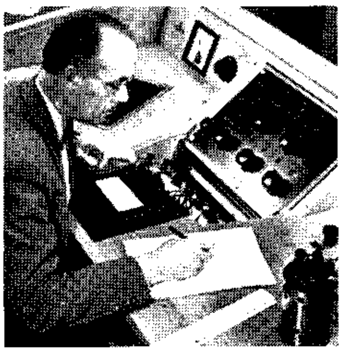

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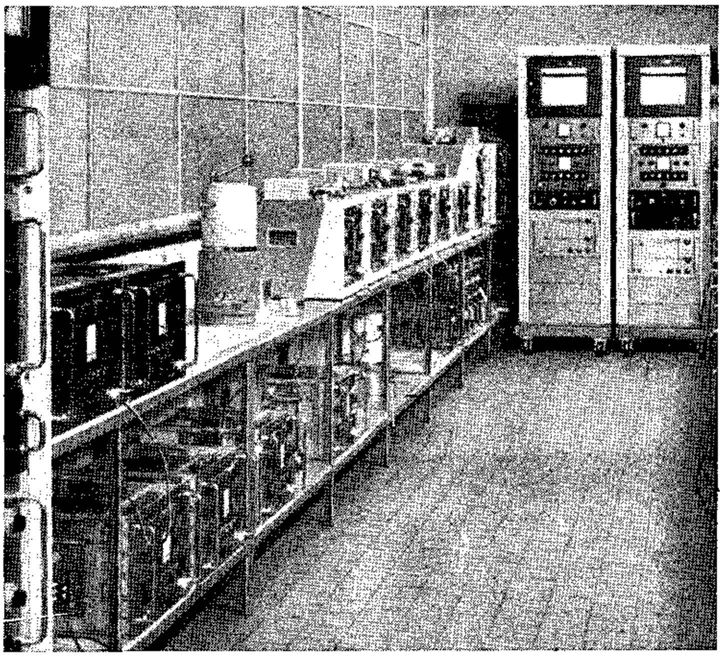

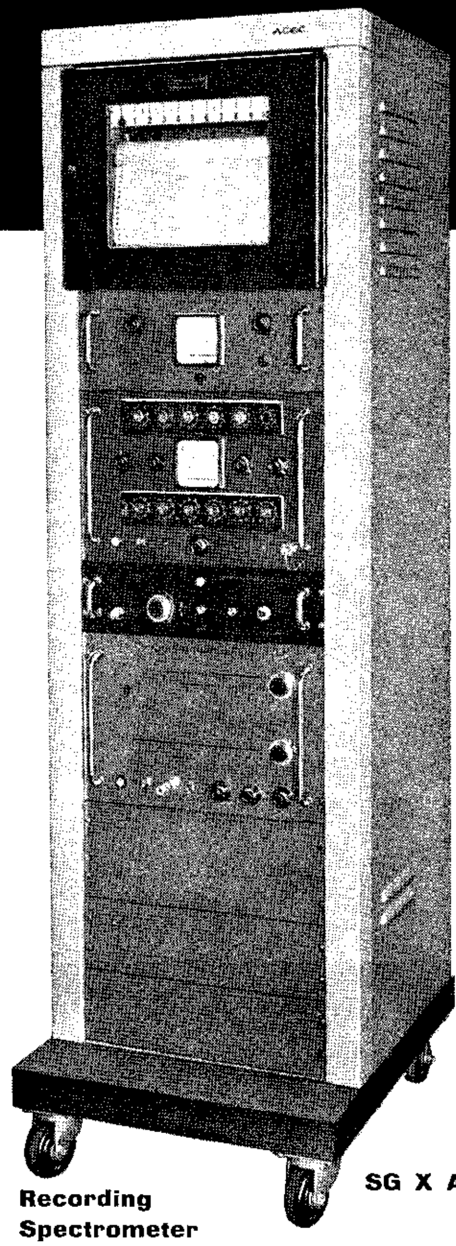

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